the difference between disk and ground taken independently of the absolute shade of the ground. In addition the darkening is dependent upon the brightness of the ground, being inversely as the brightness of this ground when the differences between disk and ground are equal. The amount of contrast is .3 of the difference between disk and ground, divided by the brightness of the ground. These laws yield the formulae, (1) $+c = K(h - H)$ where $h > H$, and (2) $-\frac{c}{h} = K'\frac{(h-H)}{H}$ where $h < H$; or $-c = K'(h-H)\frac{h}{H}$; where $+c$ indicates the brightening due to contrast, $-c$ the darkening, h the brightness of the disk, and H that of the background, K, K' constants depending on individuals and conditions. An interesting deduction from the second law is that the darkening by contrast has its maximum effect when the ground has upon it a disk of half its own brightness.

Lehmann had studied the problem of contrast with rotating disks, and Ebbinghaus is able to show that the first law is deducible from the former's results, his constant being .226. Of the second law, however, no trace is to be found in Lehmann's results, which is considered as due to unfavorable conditions of experimentation. By way of explanation of the phenomena the author believes the process to be in the retina itself, and supposes a change in sensitiveness of the different portions of the retina due to slight variations in the blood supply.

The second part of the paper is devoted to a test of Weber's law. If a series of shades be arranged, the ratios forming a geometrical progression, the intervals of brightness will not seem the same throughout the scale, as Weber's law demands, but both at the upper and at the lower ends the intervals will seem too small, while even in the medium portion slight differences can be detected. Conversely, if we arrange a series of shades that, as far as these papers allow us to do, seem equally different (the comparison being made pair by pair), we will not get an exact geometrical series. But if we have in mind only general approximate results we can say that within the limits of black and white, with which we ordinarily have to do, a series of subjectively equal intervals of sensations of brightness has objectively corresponding to it a geometrical series of light intensities. Dividing the field of shades into seven divisions, the ratio for passing from one to the other, from below upwards, was found to be 2.25, 2.11, 2.05, 1.77, 1.72, 1.68, 1.98. J. J.

Ueber die Unterschiedsempfindlichkeit für Tonhöhen. EDWARD LUFT. Philosophische Studien, IV, 4, 1888.

From the fact that we regard tone intervals as equal when the ratio of their vibration rates is the same, Fechner inferred that Weber's law is valid for sensations of musical pitch. The validity of this inference was questioned by Preyer, who suggested that this perception of the equality of intervals might be due to the occurrence of overtones and so on, and furthermore showed that the smallest perceptible difference in the pitch of two tones was not proportional to their vibration rate, but much more nearly approached constancy for all tones of a medium pitch. Luft subjects the results of Preyer and others to a fair and discerning criticism, and makes a series of observations in which care was taken to have the tones equal in intensity, the latter being the point in which Fechner saw the weak-

ness of Preyer's results. A series of tuning-forks of 64, 128, 256, 512, 1024, and 2048 vibrations per second were connected with resonator boxes that could be opened at will; on one prong of the forks was arranged a mechanism by which its tone could be slightly and measurably altered. This consisted of a screw sliding a weight up or down along a millimeter scale. The observation consisted in slightly altering one of the forks of the same vibration rates, and by several slight adjustments, first from below the point of perceptibility to above it and then *vice versa*, to infer the point when the difference was just perceptible, as also the point when the two tones were first declared equal—Wundt's well known modification of the method of "just observable difference." The result can be most briefly expressed by taking the average between the mean determination of the point of "observable difference" and the point of "equality." This is given for Luft himself in the following table:

No. of vibrations,	64	128	256	512	1024	2048
Observable difference,	.149	.159	.232	.251	.218	.362

The first number, for example, indicates that a change of .149 of a vibration per second of a fork vibrating 64 times per second is just perceptible to the ear as a difference in pitch, but, as is true throughout, without an appreciation of the direction (whether higher or lower) of this difference. If Weber's law were true these numbers should be (taking .149 or .15 as the standard) .15, .30, .60, 1.20, 2.40, 4.80. One sees at once that Weber's law does not at all hold, there being a much greater approximation to a constancy (about .2 of a vibration per second) in the just observable difference of tones between 64 and 1024 vibrations per second. Above and below this point the sensibility undoubtedly decreases, but probably not in the ratio demanded by Weber's law. Other points of importance are that the effect of practice is very marked and must first be eliminated; that this effect is decidedly greater with low than with high notes; and that the effect of fatigue is also very evident.

Luft also made some determinations by the method of "right and wrong cases," but the method is so clumsily applied that an inference from the results has little value except to corroborate in a vague way the results already recorded. He thus agrees with Preyer, though the numerical results of the two are not comparable as they stand.

This well designed study suggests comment in two directions. In the first place, granted that Weber's law does not hold for differences of pitch (and this Fechner afterwards practically admitted), how can we explain the acute perception of the equality of tone intervals, and what psychophysic bearing has this perception? In the second place, this study is unsatisfactory because it could so easily have been more valuable. It is an instance of a good observer hampered by a poor method. The object of experimentation is to reduce subjective influences to a minimum, while the method of the "just observable difference" brings them to the front. Not until results obtained in Leipzig can be repeated elsewhere with as great an assurance of reaching the same conclusion as the nature of the experiment warrants, will psychophysics be acknowledged an exact science; and the first step in that direction is the employment of controllable and logically justifiable methods. The methods employed in this research would not pass such a test. J. J.